

# The PHENIX Hadron Blind Detector

T.K. Hemmick for the PHENIX Collaboration

As our understanding of the new states of matter created in RHIC collisions increases, so too does the need for a look “inside” the medium through the use of color-neutral probes. Electrons are effective such probes, but their measurement in the PHENIX central arm is hampered by the large combinatorial background resulting from random combinations of positrons and electrons that were not created as a pair. These random combinations are dominated by the principal sources of electrons;  $\pi^0$  Dalitz decays and photon conversions. Each of these sources leaves the unique signature of a small opening angle and can be identified by a detector placed immediately following the beam pipe.

The PHENIX hadron blind detector (HBD) was built expressly for this purpose and was used for the first time in the 2007 RHIC run. Each half of the detector consists of twelve triple-GEM stacks whose top most GEM is coated with CsI, making the device photo-sensitive in the deep ultraviolet. Cherenkov light from relativistic electrons forms unfocused blob patterns on the cathode, which are then analyzed to identify electrons.

## The HBD Detector

Effects of chiral symmetry restoration are accessible in  $e^+e^-$  invariant mass spectra.

**Challenging measurement:**  
Dalitz decays and photon conversions lead to large combinatorial background.

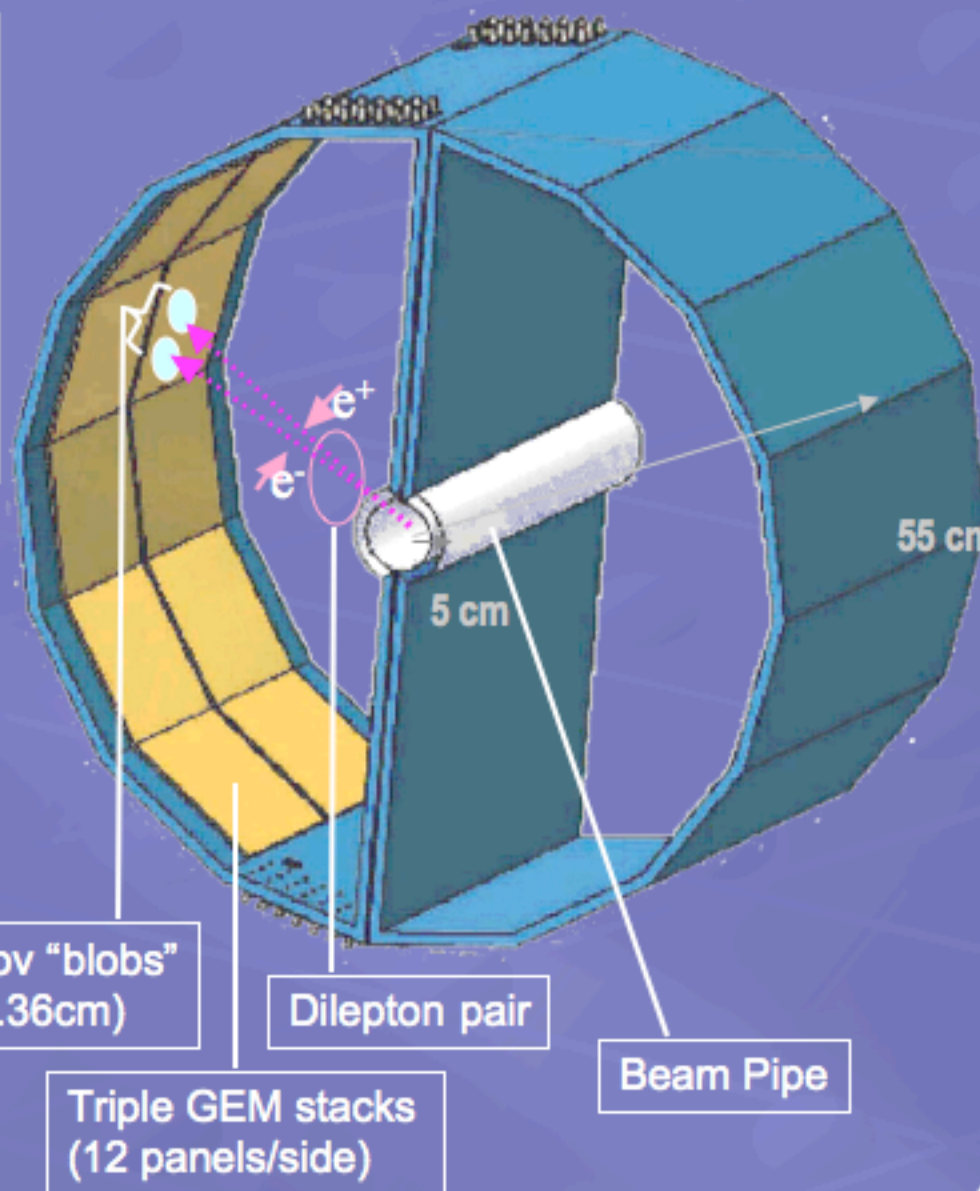
**Solution:**  
HBD identifies and vetos  $e^+e^-$  from these sources.

- Windowless Cherenkov:  
Radiator Gas = Avalanche Gas  
•  $CF_4$  ( $n \approx 1.000620$ )  
• radiator length = 50 cm

- Cherenkov light collected as unfocused blob.

- triple GEM stack
- ~300 nm CsI photocathode on top GEM.

- Radiation length  $< 3\%X_0$   
• window+gas (~0.92%)  
• vessel (~0.54%)  
• electronics (~1.5%)



## Purpose of the HBD

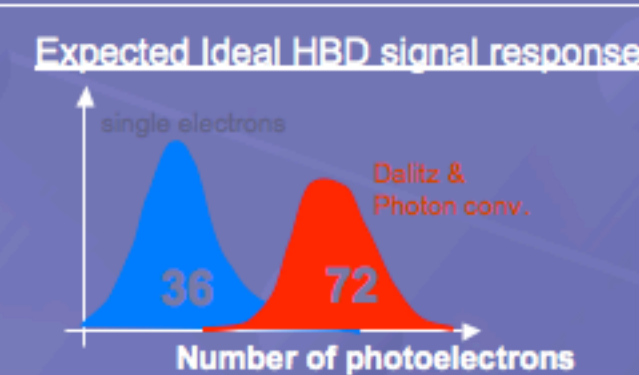
Is it a  $\pi$  or a  $\phi$ ?

A lot of particles have  $e^+e^-$  decay channels. How can we tell the Dalitz decays and photon conversions apart from the decays that we're interested in??

$e^+e^-$  pairs from Dalitz decays and photon conversions have smaller opening angles than heavy particle decays!!

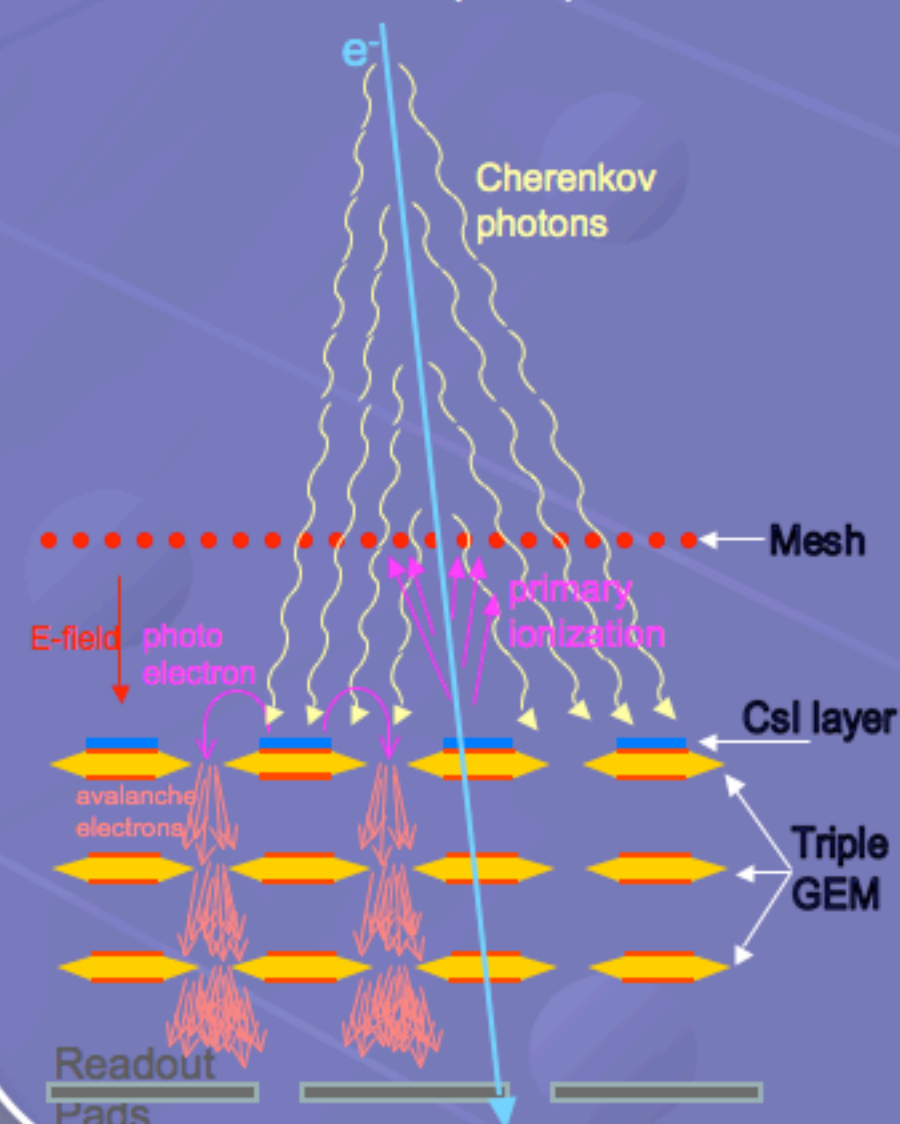
To determine one electron from two → Understanding the gain is vital!!

- The Hadron Blind Detector can**
- ID electrons.
  - give directional information.
  - determine spatial separation of  $e^+e^-$  pairs.



## Principles of Operation

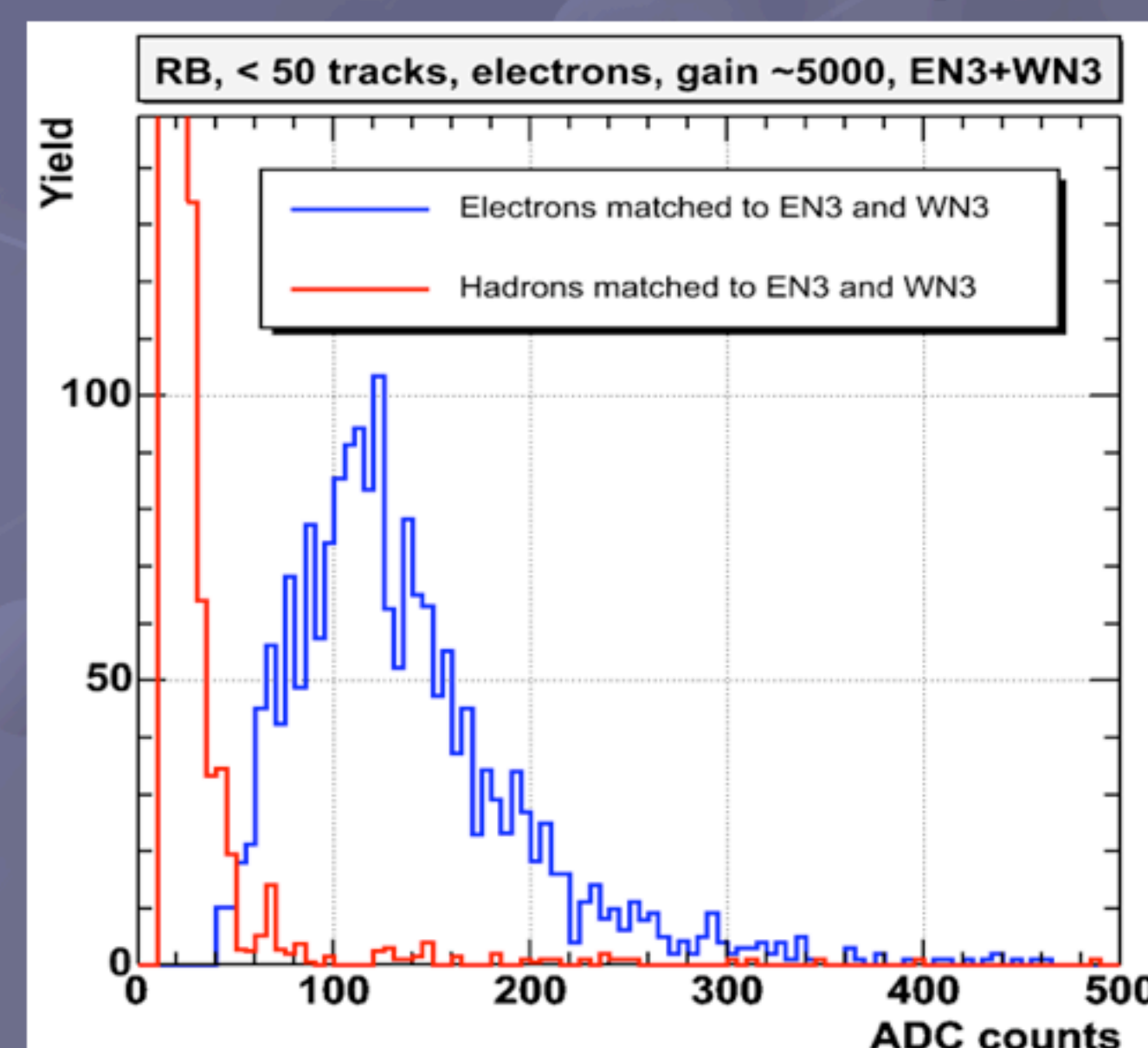
Reverse Bias (HBD)



To detect Cherenkov radiating electrons:

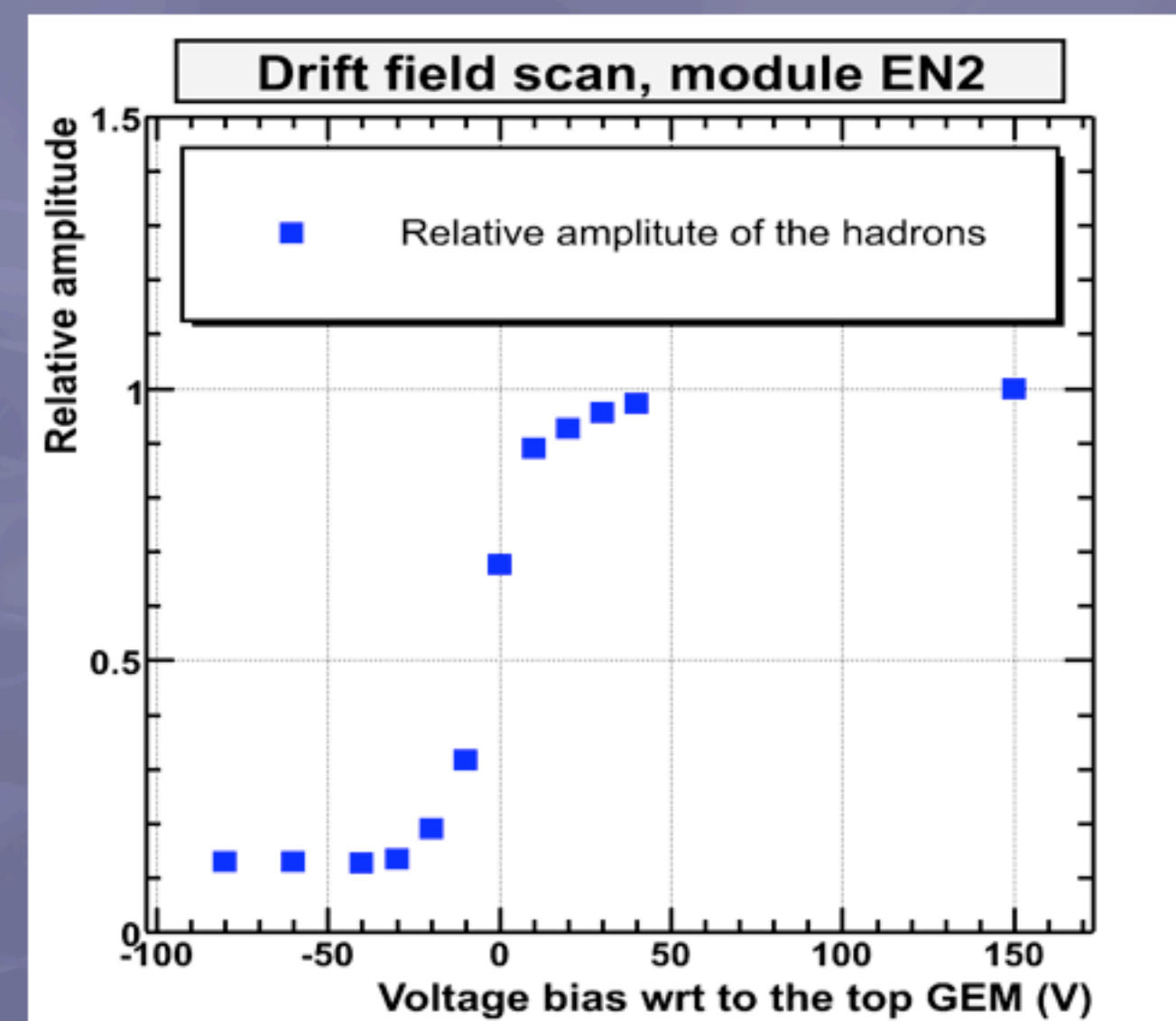
- Add 300 nm CsI layer to top GEM photocathode!
- Electron emits Cherenkov light in  $CF_4$
- Cherenkov photons impinge on CsI, ... ejecting pe's near cathode surface.
- with RB E-field, pe's are directed through gem holes
- 3-stage avalanche leads to gain between  $10^3 - 10^4$ .
- HOWEVER, primary ionization in drift gap is swept towards mesh in RB E-field!
- HBD is sensitive to UV radiation but *blind* to ionizing particles!!

## Electron Hadron Separation

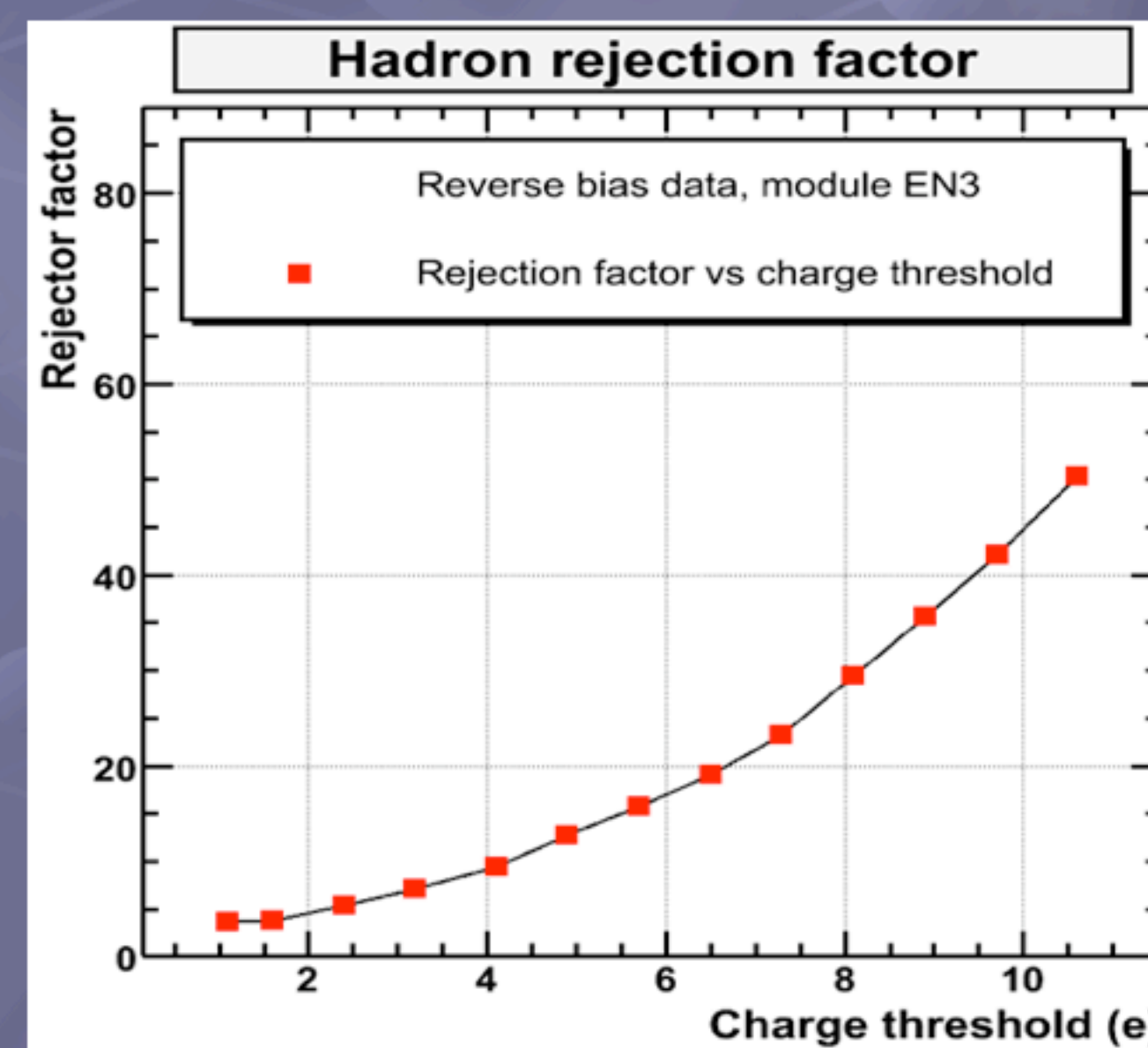


**Signal Distribution:** Shown in blue is the electron signal distribution with a reverse-bias drift field. The hadron distribution is in red.

## Hadron Rejection

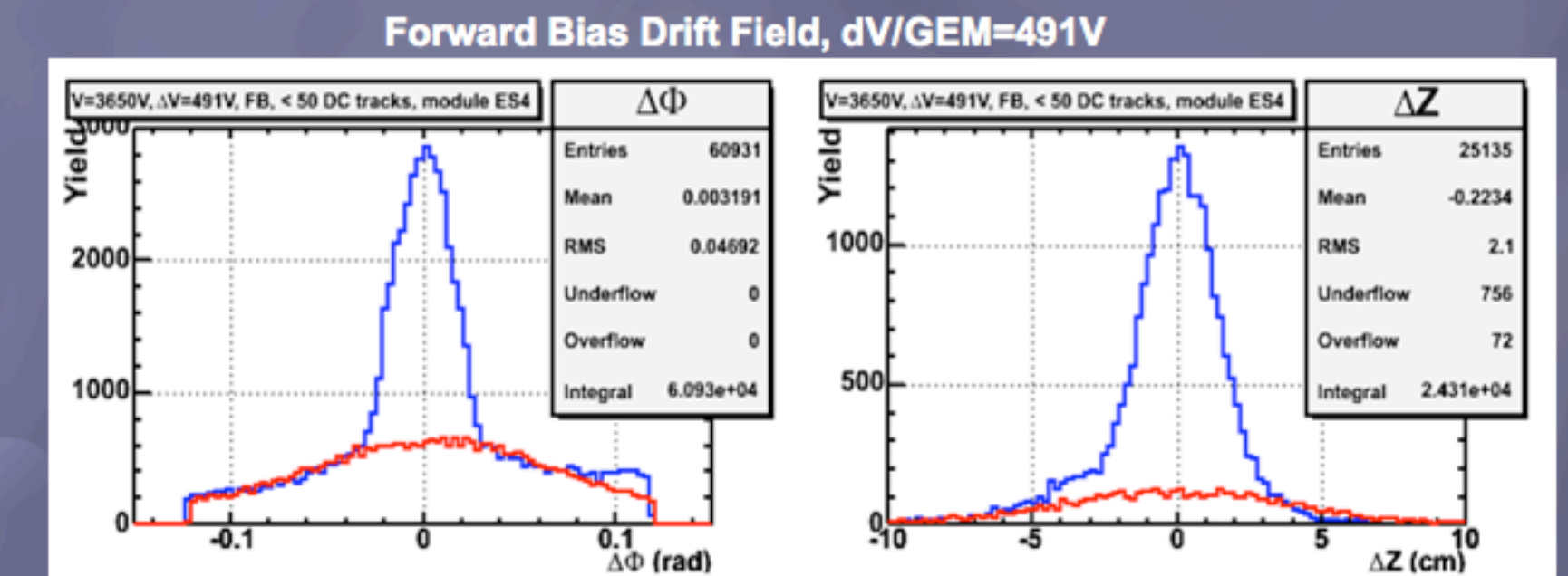


**Hadron Response to Drift Field:** Negative voltage bias (reverse-bias) in the drift gap suppresses the amplitude of the hadron signal.



**Hadron Rejection Factor:** The hadron rejection factor as a function of pad charge threshold is shown for reverse-bias drift field.

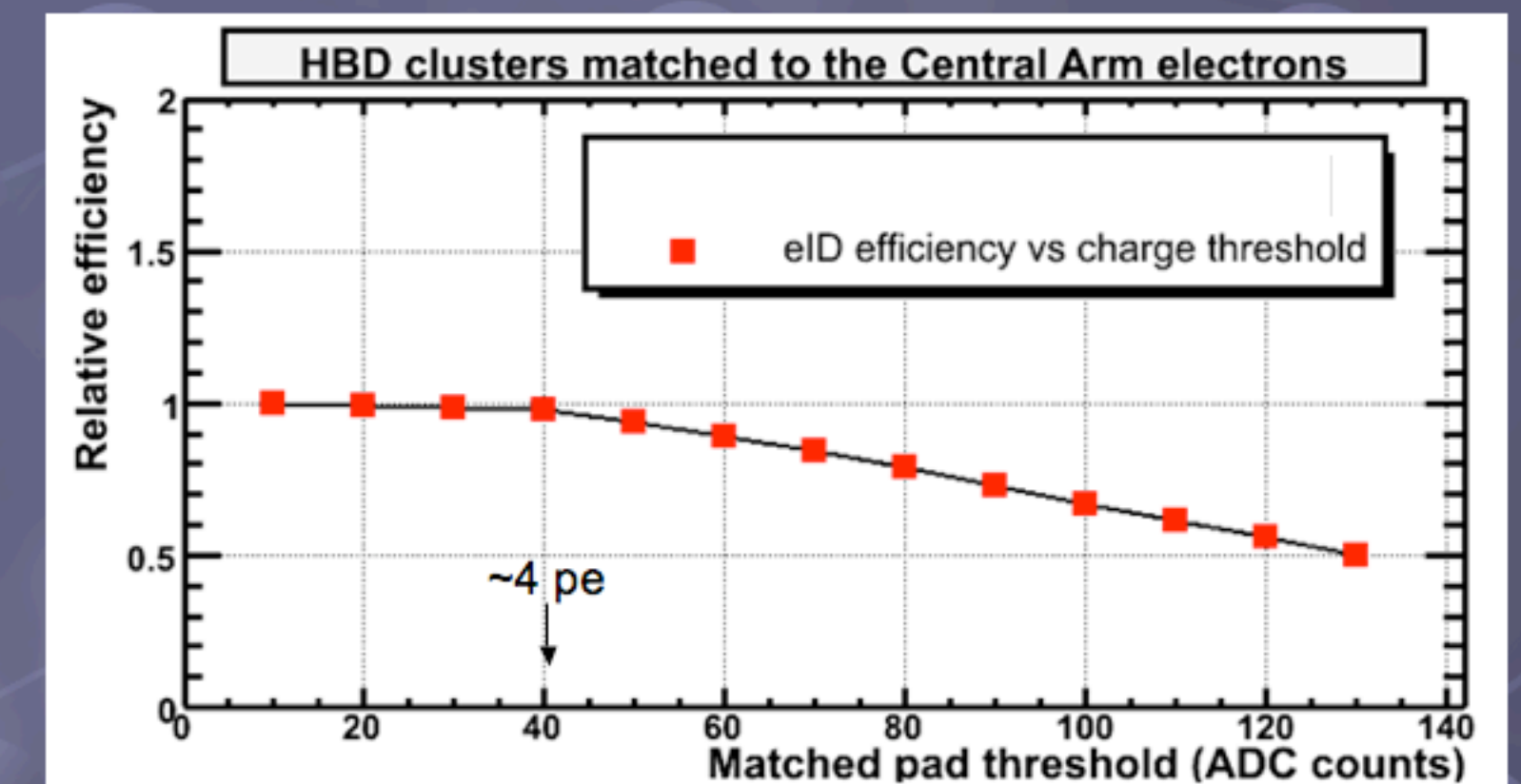
## Tracking & Position Resolution



**Track Matching Distributions:** Shown in blue is the track-matching distribution from drift chamber tracks to HBD hits. Shown in red is an estimate of random matching. This was approximated by intentionally mis-matching the east region of the HBD to the west region of the drift chamber and vice-versa.

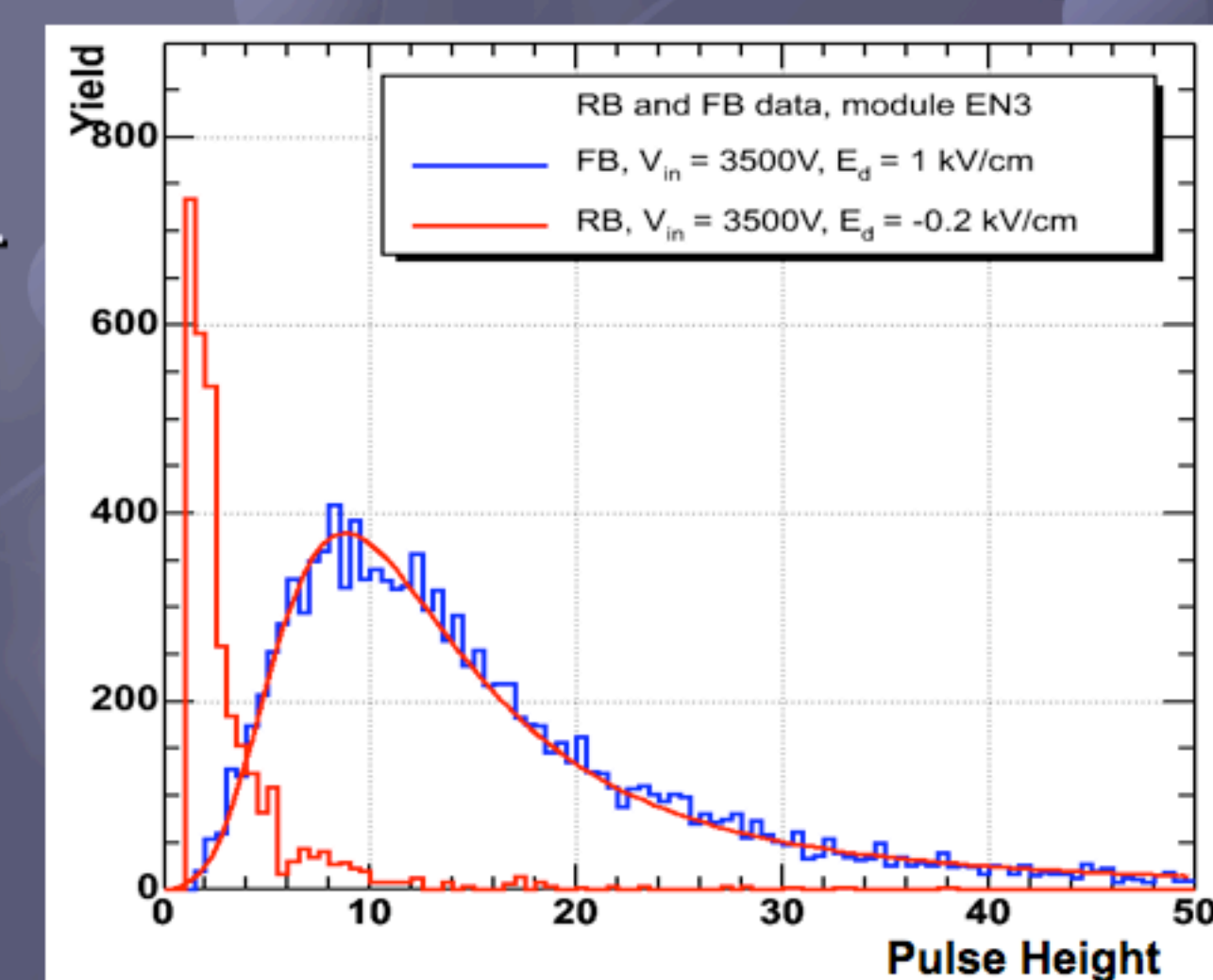
**Projected onto HBD:**  
 $\Delta Z$  in HBD +/- 2 cm  
 $\Delta\phi$  in HBD +/- 25 mrad  
**Position resolution:**  
 $\sigma_z \approx \sigma_\phi \approx 1$  cm

## Electron Detection Efficiency



**Electron Efficiency:** Electrons identified elsewhere in PHENIX are projected back to the HBD and their relative detection efficiency is obtained by varying the charge threshold of the closest matching pad. Efficiency drops at a pad threshold larger than about 4 photoelectrons (p.e.), this is probably due to electrons created by photon conversions near the GEMs.

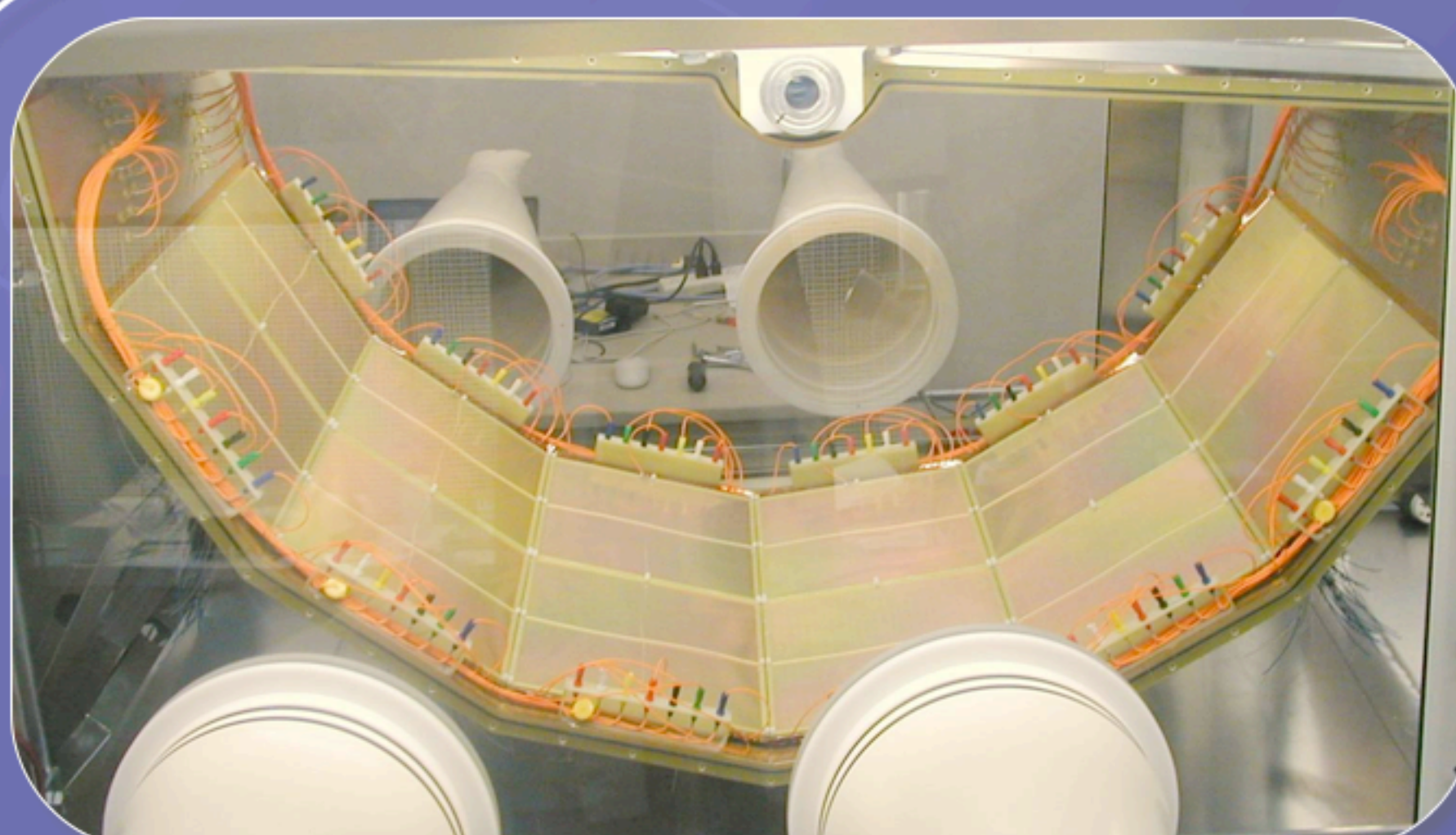
## Hadron Response



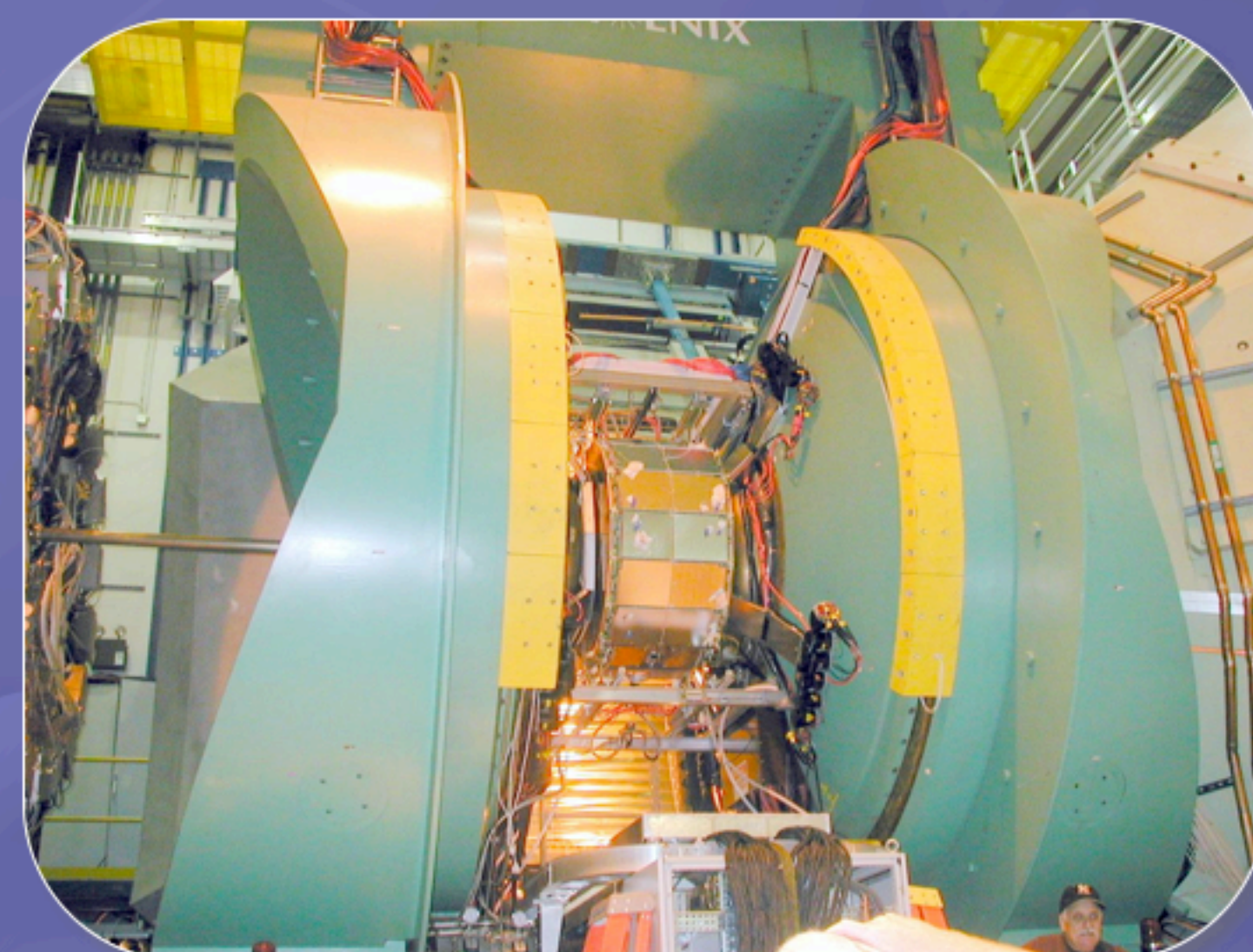
**Hadron Response:** Shown in the blue histogram is the hadron signal with a forward-bias drift field, fit with a Landau peak (red line). The sharply peaked red histogram at low pulse height is the hadron signal response to a reverse-bias drift field, highlighting the hadron suppression.

## Summary

- Low-mass  $e^+e^-$  pairs is a significant observable to diagnose the matter formed at RHIC.
- A novel HBD detector has been constructed and installed in the PHENIX set-up
- A commissioning run took place in spring 2007
- Preliminary analysis of data show:
  - Clear separation between e and h
  - Hadron rejection factor
  - Good tracking resolution
  - Good electron detection efficiency



One half of the HBD, side panels removed. The rainbow-like sheen of CsI can be seen on the 12 installed GEM stacks.



The HBD was successfully installed inside PHENIX in Oct 2006.